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Brief Report: Spontaneous attention to faces in Asperger Syndrome using ecologically
valid static stimuli

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Abstract

Previous eye tracking research on the allocation of attention to social information by individuals with autism spectrum disorders is equivocal, and may be in part a consequence of variation in stimuli used between studies. The current work explored attention allocation to faces, and within faces, by individuals with Asperger syndrome to a range of static stimuli where faces were either viewed in isolation or in the context of a social scene. Results showed that faces were viewed typically by the individuals with Asperger syndrome when presented in isolation, but attention to the eyes was significantly diminished in comparison to age and IQ matched typical viewers when faces were viewed as part of social scenes. We show that when using static stimuli there is evidence of atypicality for individuals with Asperger syndrome depending on the extent of social context. Our findings shed light on previous explanations of gaze behaviour which have emphasised the role of movement in atypicalities of social attention in autism spectrum disorders, and highlight the importance of a consideration of the realistic portrayal of social information for future work.

Keywords

Asperger syndrome, Autism, eye tracking, social attention, face perception

Abbreviations: AS, Asperger syndrome

Brief Report: Spontaneous attention to faces in Asperger Syndrome using ecologically valid static stimuli

Autism spectrum disorders (ASDs) are pervasive developmental disorders associated with a triad of impairments affecting social communication, social interactions and social imagination (Wing & Gould, 1979) that may also be accompanied by restricted and repetitive behaviours and cognitive delay. Individuals with Asperger syndrome (AS) are at the higher functioning end of the autism spectrum, experiencing the triad of impairments but usually without cognitive or language delay. Social functioning problems associated with ASDs may link to attentional abnormalities, especially attention to socially relevant information. It is not surprising, therefore, that individuals with ASDs show atypical attention to faces; critical cues for interpersonal communication.

For typical adults, faces capture attention over other types of information (Theeuwes & van der Stigchel, 2006). However, research concerning attention to faces in ASDs is equivocal. Clarifying the nature of any atypicality is important given that atypical eye contact is among the earliest clinical markers of the disorder (Volkmar et al., 1997b), and looking at faces is important for typical social development (von Hofsten & Gredebäck, 2009). To date, research has explored attention to isolated faces expressing

basic emotions (Corden, Chilvers & Skuse, 2008; Pelphrey et al., 2002; van der Geest et al., 2002); faces in social scenes representing everyday life (Freeth et al., 2010; Fletcher-Watson, Leekam, Benson, Frank & Findlay, 2009; Riby & Hancock, 2008); and faces in dynamic clips of social interactions (Frazier Norbury et al., 2009; Klin et al., 2002). While the majority of studies indicate reduced attention to social information in ASDs (most notably the eye region; Klin et al., 2002; Pelphrey et al., 2002; Riby & Hancock, 2008, 2009), individuals with ASDs have shown typical attention allocation when viewing isolated emotional faces (van der Geest et al., 2002) and social scenes (Freeth et al., 2010). This discrepancy has prompted exploration of the factors influencing gaze behaviour in ASDs. For example, the use of different stimuli (static versus dynamic) could be the cause of discrepancy, whereby atypical attention to dynamic stimuli may be driven by difficulties processing movement (Freeth et al., 2010). Alternatively, as experimental stimuli replicate more realistic social information (increased complexity, human actors, and social interactions) gaze behaviours may increase in atypicality. This would imply that even for studies involving only static stimuli, varying ecological validity may impact on gaze typicality for individuals with AS. The use of the term ecological validity in this context (and in previous literature, see Freeth et al., 2010; Riby & Hancock, 2009) implies increasing complexity and social content in order to reflect realistic social information.

Recent studies have explored the effect of different stimuli on gaze behaviours in ASDs. Speer et al. (2007) presented static images and dynamic movie extracts containing dramatic and complex social interactions. Half of the static and movie stimuli depicted one isolated individual and half depicted two or more individuals (clips previously used in Klin et al., 2002). High functioning children and adolescents with autism exhibited atypical gaze behaviour only for dynamic clips involving social interactions. Frazier Norbury et al. (2009) raised the issue of social relevance, given that these stimuli were in black and white and over 40 years old. Riby and Hancock (2009), on the other hand, used modern colour stimuli and demonstrated that children and adolescents with mild to severe autism showed gaze atypicalities while viewing still images of complex social scenes and dynamic clips of cartoons and movies with human actors, which they considered to contain enough socially realistic information to elicit atypical gaze in autism.

The present study explored attention to faces and the distribution of attention within faces by individuals with AS across a range of static stimuli. Images varied in terms of the degree of social content and context, with faces presented either in isolation (pre-selected for attention) or within a social scene, and extracted from footage of a social interaction that was either acted or from a naturally occurring interaction. A third category of isolated faces was used consisting of posed faces expressing emotions

extracted from the MindReading software (Baron-Cohen et al., 2004). All stimuli were in colour and involved human faces. It was predicted that as ecological validity increased (number of people, complexity of information, and social content), atypicalities of attention to the face, and within the face, would become more evident for participants with AS.

Method

Participants

Twenty one adolescents with a diagnosis of AS were recruited via The National Autistic Society, The Spectrum Centre in Northern Ireland and an ASDs Social Group in Queen's University Belfast. Due to calibration errors (n=5) and participant drop-out (n=2) the final sample consisted of 14 individuals with AS (aged 13y 10m to 24y 10m; mean 20y 6m). All individuals had been diagnosed by an experienced clinician according to DSM-IV criteria. Diagnosis was verified using the ADI-R (Lord et al., 1994) administered by a trained researcher (all participants with AS met the diagnostic cut-off score for autism on 3 of 4 domains).

A control group of 14 TD participants was recruited through Queen's University Belfast and other local contacts and were matched to the AS group on chronological age

(13y 7m to 24y 8m; mean 20y 4m), gender, verbal IQ and performance IQ as measured by the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999).

Apparatus

A HiSpeed eye tracking column (SMI, Germany) was utilised. It sampled at 240 Hz and had a gaze position accuracy of 0.25° to 0.5° of the visual angle. The tracking column had a chin rest and a forehead rest to minimise head movements. Analysis of eye gaze data was carried out using BeGaze Version 1.0 which has a built in saccade, fixation and blink detector. It uses a high speed event detection algorithm, due to the high speed sampling rate of the eye tracker. This algorithm detected saccades first (defined by a rapid change in gaze location), and fixations as being bordered by two saccades.

Materials

Participants viewed 56 images in total, each presented once for 5 seconds.

Isolated Faces:

Posed Faces: Twenty posed expressions were taken from the MindReading software (Baron-Cohen et al., 2004). There were ten expressions representing simple and

complex emotions (afraid, happy, sad, excited, disgusted, angry, sorry, romantic, thinking, bored), each depicted by both a male and a female actor. Visible in each image was the actor's head and shoulders against a plain white background. All of the actors wore plain coloured t-shirts.

Acted Faces: Eight faces were taken from still shots of an episode of the Mr Bean series 'The Whole Bean' (Episode 1, Part 3, entitled 'The Church'). Mr Bean is in church sitting beside another man (the actor Richard Briers). Half of the isolated faces were of Mr Bean and half were of Richard Briers. The stimuli were used to represent exaggerated expression.

Naturalistic Faces: Eight faces were taken from a clip of a naturally occurring interaction collected for research purposes. The clip involved two females involved in a non-scripted social interaction.

Isolated faces (18 female, 18 male) had eight Areas of Interest (AOIs): Eyes; Nose; Mouth; Face (excluding Eyes, Nose and Mouth); Hair; Body (from shoulders up); Background; and Other.

Social Scenes:

There were 20 scenes with two individuals per scene. Images were taken from the two clips described above (Mr Bean and naturalistic clips). AOIs for these stimuli were Eyes; Nose; Mouth; Face (excluding Eyes, Nose and Mouth); Hair; Body; Background; and a further AOI Objects (only in the naturalistic scenes). As there were two people in these scenes, gaze times to the person-related AOIs were summed.

Insert Figure 1

Procedure

Participants were tested in the eye tracking laboratory at Queen's University Belfast. They were seated 50cm from the monitor, with their chin and head resting within the eye tracking column. Participants were told that they would see different images and they were asked to watch them as they pleased (no further instruction was provided). Calibration of the eye-tracker was completed before each session using a 13 point calibration and validation. If the calibration failed or the participant could not comply with task demands they were removed from the study. The experimental stimuli were presented in a random order within each category of stimulus, and the categories were presented in the same block order – posed faces first, followed by the rest of the isolated faces, followed by the scene stimuli. At task completion participants were debriefed.

Results

Gaze behaviour was analysed by comparing the groups (AS, TD) for gaze time to each AOI separately for each stimulus category. The minimum number of trials for a category was 8, each trial lasted for 5 seconds, which equates to 40 seconds of data, and at each second the eye tracker sampled 240 times.

Isolated Faces

Posed Faces: There were no differences between the groups for total time spent fixating while viewing the Posed Faces $t(26) = .396, p > .05$. A one-factor between groups MANOVA revealed no significant main effect of Group for time spent attending to the AOIs [Pillai's Trace = .331; $F(7, 20) = 1.413, p = .254; \eta^2 = .331$] and univariate tests did not reveal any effect of Group on the allocation of attention to the individual AOIs.

Acted Faces: There were no differences between the groups for total time spent fixating while viewing the Acted Faces $t(26) = -.644, p > .05$. A one-factor between groups MANOVA revealed no significant main effect of Group for time spent attending to the AOIs [Pillai's Trace = .332; $F(7, 20) = 1.420, p = .252; \eta^2 = .332$] and univariate tests

did not reveal any significant effects of Group on the allocation of attention to the individual AOIs.

Naturalistic Faces: There were no differences between the groups for total time spent fixating while viewing the Posed Faces $t(26) = -.085, p > .05$. A one-factor between groups MANOVA revealed no significant main of Group for time spent attending to the AOIs [Pillai's Trace = .346; $F(7, 20) = 1.514, p = .219; \eta^2 = .346$]. It may be worth noting that a univariate ANOVA showed that time spent looking at the hair regions was significantly different between the groups, $[F(1, 26) = 4.809; p < .05; \eta^2 = .156]$

Insert Table 1

Social Scenes

Acted Social Scenes: There were no differences between the groups for total time spent fixating while viewing the Acted Social Scenes $t(26) = .158, p > .05$. A one-factor between groups MANOVA did not reveal a significant main effect of Group on time spent looking at the AOIs [Pillai's Trace = .383; $F(7, 20) = 1.770, p = .149; \eta^2 = .383$]. It may be worth noting that univariate ANOVAs revealed a significant effect of Group on the time spent looking at the eyes $[F(1, 26) = 7.223, p < .05; \eta^2 = .217]$ with more

looking by the TD group, and a significant effect of Group on time spent looking at the body [$F(1, 26) = 5.474$, $p < .05$; $\eta^2 = .174$] with the AS group spending more time looking at the body regions than the TD group.

Naturalistic Social Scenes: There were no differences between the groups for total time spent fixating while viewing the Naturalistic Social Scenes $t(26) = -.990$, $p > .05$. A one-factor between groups MANOVA revealed a significant main effect of Group on time spent looking at the AOIs [Pillai's Trace = .618; $F(8, 16) = 3.238$, $p < .05$; $\eta^2 = .618$]. Univariate ANOVAs revealed significantly greater attention to the eyes [$F(1, 26) = 4.830$, $p < .05$; $\eta^2 = .157$] and the face [$F(1, 26) = 4.190$, $p = .05$; $\eta^2 = .139$] by the TD participants, while looking to the nose ($p = .641$), mouth ($p = .618$), hair ($p = .205$), body ($p = .908$), background ($p = .104$), and objects ($p = .756$) were not statistically different between the groups.

Discussion

Previous eye tracking research exploring social attention in ASDs has been equivocal. Numerous studies have reported atypical attention to faces or face regions; for example reduced eye region fixations (Corden et al., 2008; Klin et al., 2002; Riby & Hancock, 2008), while others have reported typical fixation patterns (Freeth et al., 2010; van der

Geest et al., 2002). We varied the content of static stimuli to explore the effect on attention allocation to faces by individuals with AS. The spontaneous allocation of attention to faces, and more specifically the eye region, was influenced by the way the faces were presented; in isolation or within a social context. As expected, atypicalities in the AS group were more evident to more ecologically valid images.

The most notable effect of varying stimulus features was on attention to the eye region. When viewing isolated faces, participants with AS showed no atypicality of attention towards the eye region (supporting Corden et al., 2008; Pelphrey et al., 2002 but not supporting van der Geest et al., 2002). When faces were presented within social scenes, where there was additional information competing for attention, participants with AS showed atypically reduced eye region fixations (supporting Riby & Hancock, 2008). Fixations to eyes reduced as the ecological validity of the stimuli increased for individuals with AS but less so for those participants developing typically. These results are not consistent with those of Freeth et al. (2010), although, our social scenes differed from theirs in that we presented scenes of interactions between two individuals, whereas Freeth and colleagues showed one individual within a complex scene. Birmingham, Bischof and Kingstone (2008) found that increasing social content, specifically the number of people engaged in interaction, led typical viewers to spend longer looking at the eyes of actors within scenes. Differences between our findings and those of Freeth et

al. (2010) may reflect the social interaction element of the scenes. Future work could explore the effect of increasing social content on gaze behaviours associated with ASDs. Furthermore, future work should explore other more automatic and implicit indices of attention to social information across a range of stimuli, such as orientation of first fixation (Fletcher-Watson et al., 2009).

While we have shown that ecological validity is an important experimental parameter for research involving ASDs, it is also important to understand why it impacts on gaze behaviour. Theoretically, it is important to emphasise a lack of support for the notion that the face, or more specifically the eye region, is aversive in this population (Dalton et al., 2005). Our results did not suggest that participants with AS experienced aversion to the eye region in any of our stimuli. Both groups attended typically to isolated faces which, by their nature, were pre-selected for attention. However, when faces were presented in a context with other information, the TD group spontaneously prioritised information from the eyes to a significantly greater degree than the AS group. We suggest two possible explanations for this pattern which differ in terms of emphasis on social-perception or social-cognition. According to a social-perceptual explanation, participants with AS may exhibit reduced attention to the eyes because their attention was captured by other visual (and possibly non-social) information (e.g. body or background regions). In this case, participants with AS did attend to the eyes but

exhibited reduced social priority for them. Alternatively, a social-cognitive account recognises the increased social content of the scenes; thus suggesting that, despite competition from other visual information, the TD group prioritised information from the eyes because they were driven by the need to understand the social interaction (see Birmingham et al., 2008). Based on our findings, this social-cognitive drive may have been diminished in participants with AS in the current study. It is possible that such a drive could be more social (emotional) or more cognitive (dyadic/triadic perspective taking). These are speculative accounts, however, and future work should focus on teasing apart the underlying nature of attentional atypicalities in ASDs.

The present findings show that participants with AS can exhibit either typical or atypical attention to the eye region of faces depending on the nature of stimuli. Extrapolating to realistic interactions, our study did not involve people who could look back at the viewer and hold face / eye contact with them, which might be expected to increase cognitive load dramatically. In such interactions involving even greater complexity there may be further impact on the atypicality of gaze behaviours associated with AS. Further research within this domain is therefore warranted.

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Figure 1

Captions for figures:

Figure 1: Examples of Images – Acted isolated faces and scenes on the left, and naturalistic faces and scenes on the right.

Table 1: Mean (& SD) total fixation duration to the Areas of Interest in seconds for each stimulus category according to group.

Table 1

		Eyes	Nose	Mouth	Face	Hair	Body	Background	Objects
Posed Faces	AS	35.07 (15.1)	10.04 (10.03)	9.91 (5.6)	13.63 (9.1)	1.77 (1.3)	.60 (.7)	2.53 (3.2)	
	TD	33.58 (12.1))	10.86 (6.69)	14.52 (11.1)	9.80 (3.9)	1.97 (1.6)	.73 (.6)	.84 (.77)	
Acted Faces	AS	12.30 (6.4)	1.44 (1.12)	6.23 (4.4)	5.93 (4.5)	.24 (.35)	1.31 (2.0)	.83 (1.1)	
	TD	12.27 (7.2)	2.47 (3.0)	8.61 (6.2)	4.71 (2.7)	.23 (.41)	.62 (.89)	.27 (.39)	
Natural Faces	AS	9.75 (4.5)	1.81 (2.2)	1.66 (1.09)	5.25 (3.1)	3.50 (2.6)*	1.36 (1.5)	2.60 (3.4)	
	TD	12.28 (3.9)	2.01 (1.6)	2.67 (1.7)	5.52 (3.8)	1.84 (.87)*	.65 (.85)	.90 (.92)	
Acted Scenes	AS	8.40 (6.5)*	3.15 (2.0)	2.23 (3.2)	7.70 (3.6)	1.49 (3.2)	6.73 (3.5)*	5.93 (3.8)	
	TD	14.41 (5.1)*	3.43 (2.4)	2.70 (4.6)	6.19 (3.0)	.32 (.32)	4.20 (1.8)*	4.24 (1.8)	
Natural Scenes	AS	6.72 (5.01)*	3.64 (3.3)	2.00 (2.4)	4.37 (1.9)*	1.62 (3.2)	6.01 (3.6)	9.35 (4.4)	.42 (.56)
	TD	10.89 (5.02)*	4.19 (2.8)	3.54 (4.8)	6.32 (2.9)*	.37 (.38)	6.34 (4.4)	6.80 (3.1)	.49 (.64)

[*p < .05; **p < .01]